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# **APPLIED ORDNANCE TECHNOLOGY SUPPORT TO THE ONR BIOMIMETICS PROGRAM**

## **FINAL REPORT**

**GRANT #:** N00014-03-WX-20888

**PRINCIPAL INVESTIGATOR:** Dr. Randall J. Cramer

**INSTITUTION:** Indian Head Division, Naval Surface Warfare Center, Indian Head, MD 20640

**GRANT TITLE:** Biosynthesis of Energetic Materials

**AWARD PERIOD:** 1 September 2003 – 31 December 2003

**OBJECTIVE:** The goal of this project was to transition the discoveries made from the basic research in ONR's Biomimetics Program into applications that support and improve the development, manufacture, and operational use of energetic materials in military ordnance that better support the warfighter. The objective of this work was to write and submit proposals for the biosynthesis of the energetic ingredients such as, nitrocellulose, TNT, TATB, triaminoguanidine, tetrazoles, triazenes, etc., and establish and coordinate research teams to transition the new products into real applications. Technical support was provided to the Biotechnology 6.1 Program Officer of the Office of Naval Research (ONR), Molecular Biomimetics Program, Code 342, by serving as point of contact the area or energetic materials synthesis, formulation and processing and other ordnance related issues. The necessary written proposals, milestone charts, marketing strategies, customers/sponsors for transitioning biosynthesis technology into advanced development and ordnance applications were provided.

**APPROACH:** Technical support to the ONR Biotechnology 6.1 Program Officer, Molecular Biomimetics Program, Code 342 was provided by serving as point-of-contact for Navy energetic materials synthesis, formulation and processing. This involved:

- Providing technical reports on existing energetic materials programs relevant to biomimetics.
- Responding to requests and data calls in a timely manner.
- Assisting in the long-term strategic planning process.
- Transitioning the technology into exploratory development and advanced development programs.
- Aiding the development and marketing of new proposals.

## ACCOMPLISHMENTS:

- Wrote and submitted to ONR a point paper, "Low-Cost Biosynthesis of Butanetriol Precursor to Butanetrioltrinitrate," to provide background and supporting information on the Navy's need for a low cost BTTN. This white paper lead to the funding of \$1.95M to continue 6.2 research in the biosynthesis of butanetriol.
- Wrote and presented a proposal for ILIR funding to elucidate the impact of butanetriol stereochemistry on the nitration to butanetrioltrinitrate and its use in energetic formulations.
- Prepared a response to the SERDP Green Synthesis Statement-of-Need, assembled a research team, wrote a proposal, prepared a SERDP pre-brief, and presented the proposal to the SERDP Science Advisory Board.
- Wrote and submitted a Small Business Independent Research (SBIR) topic, "Alternate Synthesis Route to 1,2,4-Butanetriol (BT)," to be sponsored by the Strategic Systems Programs Office.
- Wrote and submitted a request to fund a research topic through Indian Head Division's Core Research Program focused on the stereoisomers of nitrate esters to support the Biosynthesis of Butanetriol.
- Wrote and provided a NAVFAC YO817 Business Acquisition Management submittal on the Biosynthesis of Energetic Ingredients to initiate NAVFAC a future transition sponsor.
- Obtained samples of (S)-1,2,4-butanetriol from a commercial source for stereochemical analysis and nitration to butanetrioltrinitrate (BTTN). Performed nitration and thermal analysis of products. Made contact with NRL to assist in BT and BTTN optical activity measurements. Optical activity and thermal analysis indicate that the thermal properties of racemic butanetriol are similar to those of BTTN prepared through the nitration of optically active butanetriol.
- Prepared and submitted a proposal to Naval Ordnance Safety and Security (NOSSA) to initiate investigations into the biosynthesis of high nitrogen containing explosive's precursors.
- Coordinated an arrangement between ATK Thiokol and Michigan State University to exchange information on the synthesis and acquisition costs of phloroglucinol.

## CONCLUSIONS:

The point paper submitted to ONR a point paper, "Low-Cost Biosynthesis of Butanetriol Precursor to Butanetrioltrinitrate," lead to the funding of \$1.95M to continue 6.2 research in the biosynthesis of butanetriol.

Although the Biosynthesis of BTTN SERDP proposal was invited for the Science Advisory Board presentation, the project was withdrawn due to a last minute change in project team membership.

Optical activity and thermal analysis indicate that the thermal properties of racemic butanetriol are similar to those of BTTN prepared through the nitration of optically active butantetriol.

An Intellectual Property Agreement was signed between Michigan State University and Alliant Tech Thiokol.

**SIGNIFICANCE:** Biosynthesis offers an environmentally clean, low-cost method of producing precursors for energetic materials. These modern methods will replace older polluting manufacturing processes thus providing the Navy with the needed ordnance items without contributing to the pollution of the environment and saving dollars needed elsewhere in the defense budget. Through the interactions resulting from this project the energetics and ordnance community has become more aware of the Office of Naval Research's contributions towards the development of modern Naval technology.

Specific transition options for process scale-up include:

- Biosynthesis of energetics scale-up demonstration under Environmental Security Testing and Certification Program (ESTCP).
- The use of low cost phloroglucinol in MANTECH Program in the synthesis of TATB needed at the scale of 15,000 pounds/year for the FMU-135 general bomb fuze booster.
- Reduce the cost of BTTN through commercial sources via SBIR.
- Scale-up processes through Navy Shore-side Facilities Pollution Prevention Programs (YO817).

## PRESENTATIONS:

"Green Synthesis of Energetic Materials" Joint Ordnance Commander's Group for Explosives and Propellants, AFRL/MNME, Eglin, FL July 2002.

**"Biosynthesis of Energetic Ingredients," ONR Molecular Biomimetics Program Review,  
Coolfont, WV April 2003.**